Electronics Department. Progress Report 1984

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ELECTRONICS DEPARTMENT
PROGRESS REPORT 1984

Abstract. This report summarizes the activities in the Electronics Department in 1984. These include work under the headings of informatics, applied laser physics, nuclear geophysics, instrumentation and measuring techniques, and instrumentation consulting, registration and maintenance for the Danish Research Council and Risø National Laboratory.

INIS Descriptors. GEOPHYSICS; INFORMATION THEORY; LASERS; MAN-MACHINE SYSTEMS; MEASURING INSTRUMENTS; OPTICS; RESEARCH PROGRAMS; RISØ NATIONAL LABORATORY.

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INTRODUCTION

This report reviews activities within the Electronics Department during 1984. The sections in the report correspond to activities within various groups in the department. Each section consists of an introductory portion followed by more detailed information together with relevant references on specific projects. The report is intended to serve as one way of maintaining the department's contacts with colleagues, both in Denmark and abroad, as well as other interested parties.

The Electronics Department at Risø comprises about 90 people and is made up essentially of two main divisions. One deals with the provision of instrumentation and measurement expertise for the different groups at Risø who conduct basic research or technological R and D. This division employs a research instrumentation group, a maintenance facility and a central instrument pool for the complete site.

The other division is engaged in basic and applied research, and includes activities in three main areas which all have been affected by the general technological development in Denmark during recent years. The work on **human factors** in risk and reliability analysis and process control has been redirected towards a broader program in human-computer interaction with involvement in research programs within information technology, such as the European ESPRIT program. The **applied laser physics** program, which has been focussed on remote sensing, is now emphasizing research on optical information processing. Finally, the activities within geophysical methods for **uranium prospecting** are now being moved to measuring techniques for mineral resource exploitation in the oil and gas domain, as a consequence of the decision to remove nuclear energy from the Danish national energy plan.

Activities within the Electronics Department have reflected the continued trend within Risø as a whole which in recent years has involved the Establishment in an expanding set of external contract-based programs. As far as the Electronics Department is concerned, contract activity in 1984 amounted to approx. 30 of the total budget. In practice, these contracts ranged from partial support of research and development efforts (typically from national foundations, international bodies) to contracts from other governmental agencies for special studies, systems, etc. to commercial agreements in connection with consulting,

service, maintenance, etc. This line of development is expected to continue. For details on the service-oriented activities in the department, a separate report (in Danish) - Risø-I-215 - is available.

INFORMATICS

Introduction

The year 1984 has been characterized by a significant interest and activity in advanced information technology over almost all of the industrialized world. A direct impetus to this increased attention to advancing the state-of-the-art is the well-publicized Japanese effort which aims at the development of the so-called "Fifth generation of computers". This has been closely followed by similar large-scale programs in the USA, and UK (with the Alvey Program), the European Community (with ESPRIT) as well as various other national and international efforts. In Denmark, for example, the Technology Council has the equivalent of a $150,000,000 program to support Danish industry, among other things, in the use of advanced information technology in product development as well as in production and manufacturing processes.

This has had some implications for the work program of the Informatics Group (earlier reported under the heading of System Techniques) - as yet without any serious repercussions. The group's early interest in reliability and safety and, in particular, human reliability had resulted in a long-term R and D program which aimed at establishing a suitable basis for the design of what could be called "error-tolerant" human-machine systems, especially in the context of supervisory control of industrial process plants. This work has proved to have given the proper prerequisites for an active participation in some of these newer efforts dealing with informatics and information technology. In addition, the group's activity sphere is an important ingredient in Risø's overall strategic planning in this area.

As in the previous reports, the activities during 1984 will be discussed under Conceptual Studies, Experimental Program, Applied Work and Support Functions.

Conceptual Studies

Cognitive Task Analysis

Previous reports have dealt with many of the ingredients of the conceptual base which is constantly under development to give a

solid framework for the design and evaluation of human-machine systems - especially within the domain of supervisory control in industrial plants but also within the more general context of decision making in the control room as well as in administrative planning and diagnosis.

Figure 1 gives a composite view of some of the elements in this conceptual base and attempts to locate their relevance in the creative process (which could be called cognitive task analysis) required to proceed from systems requirements to a human-machine interface design. These include the **decision ladder**, the two-dimensional decision space comprising **whole-part** considerations as well as a **means-ends** (or abstract-concrete) thinking as well as suitable **strategies** for searching in systems in order to locate faults, causes, solutions, etc. Reports on some of these subjects are abstracted below.

A new activity has been started as a PhD project which seeks to find suitable methods and techniques for probing human behaviour in order to uncover useful information about mental models and strategies. This is also relevant for the group's experimental work. Indeed preliminary results indicate the importance of this type of probing in order to understand the performance of subjects doing diagnostic and state identification tasks.

It is clear that all of this work serves as an important foundation for the applied work discussed later.

Specific references and abstracts:

The elements of a cognitive task analysis: The abstraction hierarchy, the decision ladder, and mental strategies have been discussed in detail with reference to the diagnostic task of industrial process supervisors.

Rasmussen, Jens, "Strategies for State Identification and Diagnosis in Supervisory Control Tasks, and Design of Computer-Based Support Systems". Advances in Man-Machine Systems Research, Volume 1, pages 139-193. JAI Press Inc., 1984.

> A framework useful for understanding and designing supervisory control systems is presented. Topics discussed include cognitive task analysis, hierarchical system representation, descriptive and prescriptive strategies for diagnosis, and phases of the system design process. The proposed framework is used to provide an integrated perspective of

these topics in terms of implications of trends towards increasingly complex systems and sophisticated computer-based information technology.

Multi-Level-Flow Modelling

The multi-level-flow modelling techniques (MFM) are used for describing complex systems such as power plants, etc., in terms of a decomposition of interrelated mass and energy flow structures. The method leads to a description of system goals and functions and gives a useful basis for dealing with various aspects of system analysis, design and specification.

The method is under continual development and refinement and has already been utilized by utilities and system suppliers.

References:

Lind, M., "Information Interfaces for Process Plant Diagnosis". Presented at the Conference on Data Communication in Distributed Systems, organized by the Danish Automation Society. Available as report (Risø-M-2417).

A systematic approach to the design of information interfaces for operator support in diagnosing complex systems is described. The need for interpreting primary plant data within the framework of different system representations organized into an abstraction hierarchy is identified from an analysis of the problem of diagnosing complex systems. A formalized approach to the modelling of production systems, called Multilevel Flow Modelling, is described. A so-called MFM model specifies plant control requirements and the associated need for plant information and thus provides a consistent context for the interpretation of the actual dynamically varying plant data, e.g. in a diagnosis situation. The use of MFM models as a basis for the functional design of the plant instrumentation system is outlined, and the use of "knowledge-based expert" systems for the design of human-machine interfaces is mentioned. Such systems would allow an active user participation in diagnosis and thus provide a good basis for cooperative problem solving and decision making.

Probability Bounds for Systems with Partially Specified Dependencies

Consider a fixed set of n events on a probability space. Let the probability system under consideration be specified by S_1, the sum of the probabilities of occurrence of each event and S_2 the sum of the probabilities of occurrence of each of the pairs of events. Using a dual linear programming technique, sharp upper and lower probability bounds are derived for various logical functions of the number of event occurrences. A paper describing the work will appear in J. of Appl. Prob. 1985.

References and abstracts:

Platz, O., "A Markov Model for Common-Cause Failures". Reliability Engineering 9 (1984) 25-31.

A continuous time four-state Markov chain is shown to cover several of the models that have been used for describing dependencies between failures of components in redundant systems. Among these are the models derived by Marshall and Olkin and by Freund and models for one-out-of-three and two-out-of-three systems with identical components.

Platz, O., "Sårbarhedsanalyse af to forslag til udbygning af det danske civilforsvars varslingssystem". Society of Reliability Engineers, Symposium '84, October 16-17, 1984, Vaxjo, Sweden. 18 pages.

Experimental Program

As a parallel activity to the conceptual studies, an experimental facility built around a simulated process plant is used to carry out investigations on selected topics regarding human-computer cooperation in decision making. As was reported last year (see Risø-M-2434), some preliminary and exploratory experiments were run using the first version of the system. These attempted to assess the ability of the subjects to identify the state of the process plant (a simplified PWR type of system) on the basis of information about the mass and energy in the system.

Since then, the facility has been expanded and improved and the available display set has been extended to include a second level of information about equipment state and capabilities. An example of the mapping from the functional level (describing

mass and energy) to the equipment plane is shown on Figure 2. Thus the emphasized portion of the "procesoversigt" gives information on the physical resources (pumps, valves, etc.) required to realize the function "maintain secondary flow" which is displayed in the top figure. The user can, by means of a touch panel, quickly move between the two levels.

Studies wil be carried out on the acceptability and usefulness of the two levels in order to learn more about human subjective criteria for selecting the one or the other as a function of background, training, experience.

Applied Work

Expert Systems

Expert systems to assist the process operator in diagnosis and control are attempts to utilize techniques and tools from artificial intelligence to structure a computerized aid which is capable of "reasoning", for example about the state of a process plant from an analysis of actual plant data using an internal representation of the plant and following a stored set of strategies and rules for controlling the diagnostic process.

The multi-level approach mentioned earlier is an admirable basis for describing and representing the plant structure and characteristics and forms part of the Risø contribution to a European Community ESPRIT project on an "Expert System Builder" for diagnosis in electronic systems and process control. This project, which in Denmark involves S. T. Lyngsø A/S as well as Risø, is now in its second year.

Human Reliability

In this work human risk contributions are being studied by investigating the breadth of coverage through the use of predictive search strategies in analyzing work situations in combination with a suitable Risk Management activity emphasizing the use of post-incident analyses.

The work employs the human behaviour modelling and error taxonomy previously developed.

Previous work (NKA/LIT-1(84)107) indicated the search strategy: Work Analysis, as a promising tool for well-structured activi-

ties, such as test and calibration in process plants, and also that post-incident analysis of human errors would strongly support Risk Management.

During 1984 support (NKA/LIT-1(84)105) was given to a final application of Work Analysis performed by Studsvik Energiteknik AB as a part of the NKA/LIT-1 project on Human Reliability in Test and Calibration. The experience and results accumulated from this project were collected in a report (NKA/LIT-1(84)106) which, for the purpose of promoting immediate practical application, was written as guides for the predictive and also retrospective analysis of human risk contributions in process industry.

A proposal (Leplat and Rasmussen) was given for the application of the human behaviour modelling to the improvement of less-structured activities of the kind involved in occupational accidents. The proposal includes the use of the Variation Tree method of French origin. For evaluating the practicality of the proposal a project was worked out and financial support applied for.

References:

Leplat, J. and Rasmussen, J., "Analysis of Human Errors in Industrial Incidents and Accidents for Improvement of Work Safety". Accident Analysis and Prevention, Vol. 16, No. 2, 1984.

Methods for the analysis of work accidents are discussed, and a description is given of the use of a causal situation analysis in terms of a "variation tree" in order to explain the course of events of the individual cases and to identify possible improvements. The difficulties in identifying "causes" of accidents are discussed, and it is proposed to analyse accident reports with the specific aim of identifying the potential for future improvements rather than causes of past events. In contrast to traditional statistical analysis of work accident data, which typically give very general recommendations, the method proposed identifies very explicit countermeasures. Improvements require changes in human decisions during equipment design, work planning, or the execution itself. The use of a model of human behaviour drawing a distinction between automated skill-based behaviour, rule-based "know-how" and knowledge-based analysis is proposed for identification of the human decisions which are most sensitive to improvements.

NKA/LIT-1(84)105
A: Kommentarer vedrørende afprøvning af arbejdsanalyse
B: "Preliminary Procedure for Work Analysis 1984-01-13"

The following is presented to support Studsvik Energiteknik AB in their trial test of Work Analysis: a search strategy for risk contributions from well-structured human activities: A) Proposals for delimitation of the extent of the trial test and for guiding the systematic recording of preconditions and assumptions during the test (in Danish). B) An up-dated version of the Work Analysis procedure.

NKA/LIT-1(84)106
Human risk contributions in process industry: Guides for their pre-identification in well-structured activities and for post-incident analysis

The report should be considered a guide for the treating of human errors: for identifying their possibilities of occurrence when designing well-structured human tasks and for their improvement when they occur in reality.
For these purposes a strong coupling between predictive and retrospective analysis is emphasized: In order to control human errors, post-incident analysis of cases with human errors in a given industrial plant should be performed as means of feedback from reality for the verification of results of predictive analysis and also as a general means of identifying and improving such human errors which cannot be expected covered by predictive analysis.

Primarily, the guide addresses people with a knowledge of the technical plant in question and involved in the safety-oriented design and improvement of human activities and without a particular human factors background.

The main report describes the procedures for post-incident analysis and for Work Analysis, which is a search strategy developed for well-defined activities, e.g. test and calibration, and constitutes a formalized procedure for the pre-identification of relevant human errors leading to a lack of task result and/or to immediate effects not covered by the lack of task result itself.

Work analysis and the post-incident analysis procedures are based on a common description system for human malfunctions.

This system is explained in appendix and so are its underlying models and way of reasoning.

Finally, a word index is provided for supporting the reader.

Four references. In English.

NKA/LIT-1(84)107
Human errors in test and calibration: Analysis of actual events for the evaluation of coverage and applicability of search strategies and risk management. Summary report.

The report is a summary in English of a study of human errors in test and calibration as documented by cases from nuclear power plants: Ten from Swedish plants and described in detail, 70 from American Licensee Event Reports.

In a previous report the following concept was advocated: The information provided by performing a Probabilistic Risk Assessment (PRA) or an As-operated Safety Analysis Report should be used as reference for a closed-loop risk control

or risk management utilizing post-incident analysis as means of feedback of operational experience.

On the precondition of employing this concept the study aimed at the following:

1) To have indicated which typical human errors could be expected covered by established PRA methods and which could not and, consequently, should be controlled by some kind of risk management.

2) To have indicated the applicability of two typical predictive search strategies: Work Analysis, seeking for significant human error effects internal or external to the task, and Risk Analysis, seeking for significant causes, particularly human ones, of critical events.

Summary results and conclusions are presented.

Seven references. In English.

Operator Training

The two main purposes of the project are as follows:

1. To develop and test training methods for normal conditions as well as transients, including transients that cannot be implemented on a full-scale simulator.

2. To develop and test a method for systematic observation, analysis and interpretation of operator performance in a training session.

As the project now is well into its data collection phase the practical implications and emphasis can be stated:

a. The training method mentioned in the first purpose concerns fault finding techniques using diagnostic search strategies and rules. The main emphasis is here to formulate a set of diagnostic rules, teach nuclear plant operators to use these rules and test the impact of rule utilization on the operator fault finding performance during simulator training.

b. Emphasis has also been put to collect data about the attitudes of the operators concerning their motivation to learn diagnostic search methods, to which extent they are prepared to use diagnostic rules during simulator training and in their work at the nuclear plant, to what degree they felt that the diagnostic rules helped them during the simulator sessions, etc.

c. To fulfill the second purpose of the project a observation form has been developed and used during the simulator sessions. The advantages and disadvantages when using this form have yet to be analysed.

Twelwe diagnostic rules have been formulated from data aquired from interviews with three crews from the Swedish nuclear power station at Ringhals. The theoretical structure of these diagnostic rules is based on the following model and concepts:

- The chain of event and activities **from** the discovery of a deviation from normal values or a fault **to** activities to correct the deviation/fault have been carried out is called a **search sequence**

- This search sequence consists of a number of **search phases** formulated as general directions labelling main search activities to be considered during the search sequence.

- Each search phase has two principal aspects attached to it, namely a **technical aspect** which consists of the technical knowledge required to deal with the affected system and a **procedure aspect** which contains information about how to proceed when searching through the faulty system.

- The technical aspect is not dealt with in the project, i.e. no technical rules are stated. The procedure aspect consists of **search modules** which state different dimensions of the search procedure.

- **Diagnostic rules** are then formulated in order to cover these dimensions of the search procedure.

The idea behind the dividing of the search phases into two aspects comes from practical reasons of which the most important is the fact that the complexity of the systems within a nuclear plant makes it practically impossible to cover all incidents by diagnostic rules.

The twelve diagnostic rules were presented to the experimental group consisting of six crews at Ringhals during a five hours course. The performance of these crews are to be compared with the performance in the simulator at AKU of five other crews at Ringhals which have not participated in the course. The purpose of this comparison is to find out whether the crews are using the diagnostic rules or not and if so, to what extent thay are helped in dealing with the simulator transients. As the technical aspect of the search sequence is not dealt with during the course the outcome of the comparison will give hints about the value of implementing formal search strategies in the regular nuclear plant operator training from a procedure aspect point of view.

The activities within the project during 1984 can be summarised as follows:

- Arranging interviews and simulator study in practical terms.

- Carrying out interviews during two periods with three crews at Ringhals.

- Construction of five observation and attitude forms to be used in the data collection at AKU.

- Preparation of the content and AV materials for a three day instructor's course at AKU in order to train the instructors in observation methods etc.

- Interviews with the AKU instructors about simulator procedures etc.

- Determine the experimental transients to be used during the data collection.

The following activities are planned for the first six months of 1985:

- Carrying out of the AKU instructor's course in January.

- Data collection from the simulator sessions at AKU concerning eleven crews from Ringhals starting in the middle of February and ending in the end of April.

- Data analysis during May.

- Writing of the project report from the beginning of May to the end of June.

The project is proceeding according to the plans.

Other Activities

An industry meeting was held at Risø in October for the purpose of updating the group's contacts with other institutions and industrial companies and informing them about the work being done. The program included many of the points discussed in this report.

Several members of the group participated as invited speakers in the conferences in Denmark dealing with control room operators and their coming role in the light of the foreseen technological developments. In addition, an invited talk was given on "Human-Machine Cooperation in an Information and Nuclear Society" as part of a series of lectures supported by the Danish Academy of Sciences.

On the international plan, the following conferences were attended and papers presented:

Rasmussen, Jens, "Cognitive Control and Human Error Mechanisms". Invited paper presented at Workshop on New Technology and Human Error in Bad Homburg, February 13-15, 1984.

Rasmussen, Jens, "Human Error Data, Facts or Fiction?". Invited paper presented at a seminar on Accident Research in Rovaniemi, Finland, April 1984. N-6-84.

Rasmussen, J. and O. M. Pedersen, "Human Factors in Probabilistic Risk Analysis and in Risk Management". Reprint from Operational Safety of Nuclear Power Plants, Vol. 1, IAEA, Wien, 1984.

Support Functions

Local Computer Centre

The local computer centre at the Electronics Department consists of a VAX 11/750 computer and three PDP-11/34 minicomputers (all from Digital Equipment Corporation).

The VAX is a multiuser system with possibility for connection of more than ten users simultaneously.

In order to facilitate any in-house user to connect to the VAX or via the Risø datanet to B7800 or the THOR system, a switchboard has been built. Data connections have been established between any office module in building 130 and the switchboard, allowing a simple connection of a "private" terminal in the user's office and any of the systems mentioned above.

Via the switchboard it is possible to transfer data between different personal computer systems in the department, or between a personal computer and the VAX.

The department is participating in the ESPRIT project 96 around Expert Systems for Diagnosis.

The VAX is partly used for this work, and a telephone line has been established to let the other partner in the project use the

VAX mailing service for a better coordination of cur mutual work.

One of the PDP/11s is used on an "open shop" basis by other groups or departments inside Risø.

The centre previously had an EAI-680 analog computer (from Electronic Associates Inc.), but in June 1984 it has been transferred to the H. C. Ørsted Institut, who was the largest user.

Systems Programming

The local computer centre provides system support to other minicomputer installations (PDP-8 and PDP-11) at Risø.

GNP Assistance

The programming group is assisting in development of software for the extended GNP (generic nuclear plant) man-machine experiments.

Special efforts have been spent on the coming version of the system: GNP-III which is supposed to run in a PDP-11, making a real-time simulation of the power plant process, and using the APPLE III as an intelligent graphical terminal.

Other Activities

The RIKKE programs for hazard analysis - fault tree construction and the FAUNET programs for fault tree calculations have been transferred to the VAX computer.

Two copies of the whole package have been sold to other institutions in Europe.

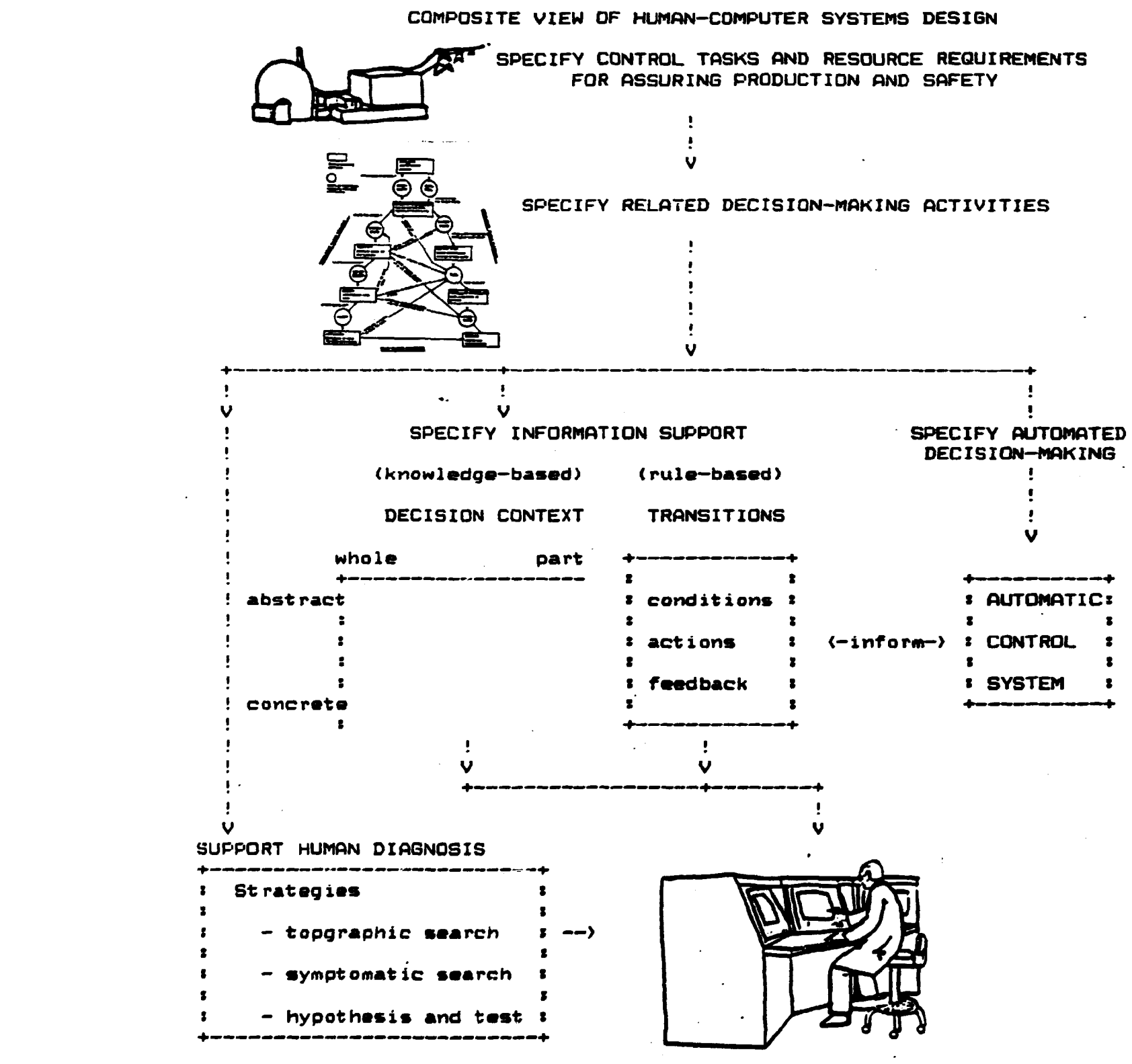
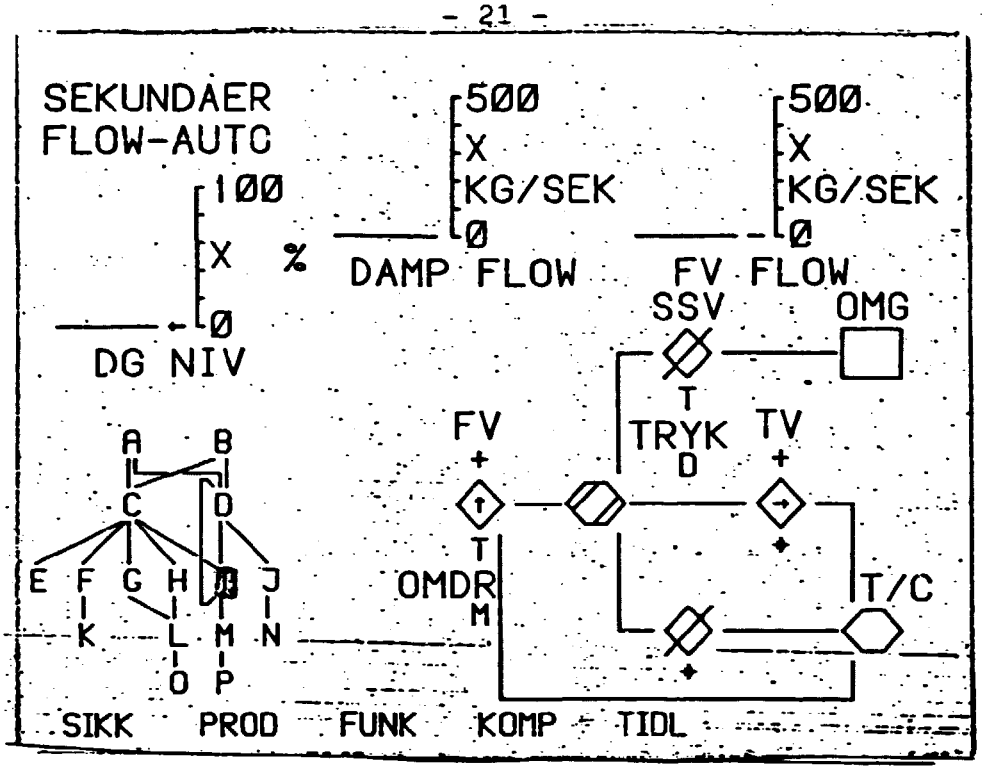

COMPOSITE VIEW OF HUMAN-COMPUTER SYSTEMS DESIGN
SPECIFY CONTROL TASKS AND RESOURCE REQUIREMENTS FOR ASSURING PRODUCTION AND SAFETY
SPECIFY RELATED DECISION-MAKING ACTIVITIES
SPECIFY INFORMATION SUPPORT
(knowledge-based)
(rule-based)
DECISION CONTEXT
TRANSITIONS
whole
part
abstract
concrete
conditions
actions
feedback
SPECIFY AUTOMATED DECISION-MAKING
AUTOMATIC CONTROL SYSTEM
(-inform-)
SUPPORT HUMAN DIAGNOSIS
Strategies
- topgraphic search
- symptomatic search
- hypothesis and test
-->

FIGURE 1



FUNCTION

TO

EQUIPMENT MAPPING

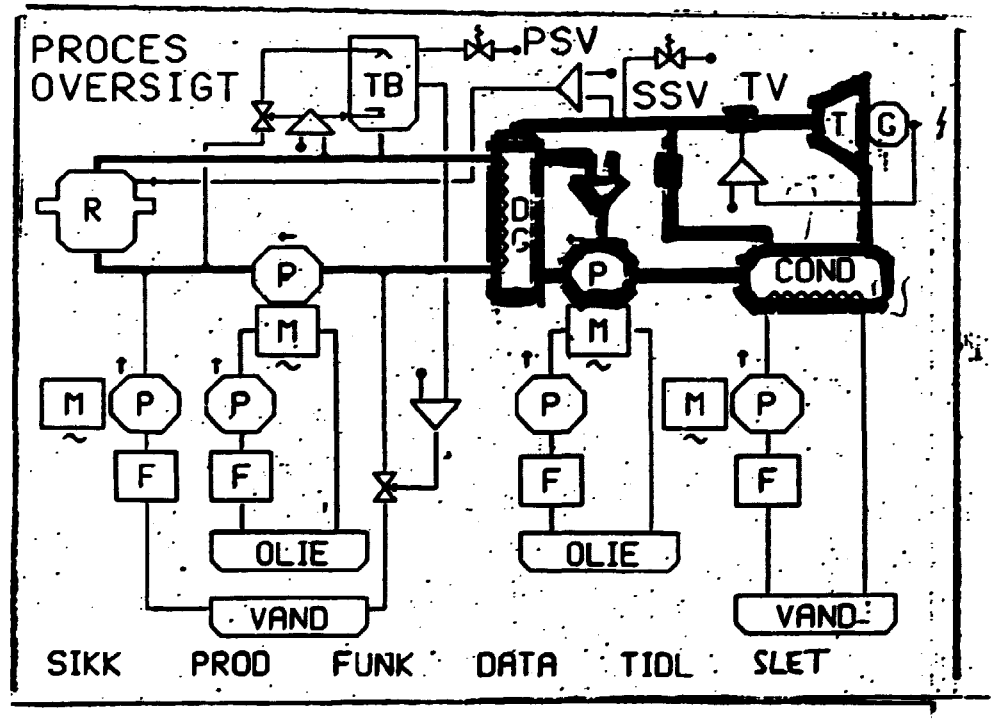


FIGURE 2

	POWER PLANT	ELECTRONICS DEPARTMENT
PURPOSE	Production goals	Technical/Scientific output
	Safety Requirements	Constraints (legal,economic, time
ABSTRACT FUNCTION	Mass,energy,information flow	Money,material,information flow
GENERALIZED FUNCTION	Heat transfer Feedback Combustion	Research Technical Services Administration (function/project-based)
PHYSICAL FUNCTION	Boiler,pumps, condenser (system,subsystem, component-related)	Data processing, drawing office, secretariat (group/individual-based)
PHYSICAL FORM	Appearance, construction location.	Site information Inventory Personnel

FIGURE 3 EXAMPLES OF DESCRIPTIONS AT VARIOUS LEVELS OF ABSTRACTION

GOALS	Professional output Economic status
ABSTRACT FUNCTION	Production volume Flows of funding, resources. Distribution of funding sources, sinks. Transaction-related information flow Organisational couplings
GENERAL FUNCTION	Function/project-related budget, expenditures,output
PHYSICAL FUNCTION	Facility/group-related budget, expenditures,output
PHYSICAL FORM	Inventory - usage, maintenance Personnel-related information

FIGURE 4 - EXAMPLES OF QUANTITATIVE INFO

GOALS	Laws, regulations
	Market analyses
	Acquisition goals
	Public opinion
	External involvement
	Internal collaboration
ABSTRACT	Minutes of meetings
GENERAL	Procedures, directives
PHYSICAL	Publications
FUNCTIONS	
PHYSICAL	Catalogs,manuals
FORM	Drawings
	Transaction forms and procedures
	Computer programs and data files
	Personnel lists

FIGURE 5 EXAMPLES OF OTHER INFORMATION

APPLIED LASER PHYSICS GROUP

Introduction

Optical Metrology and Signal Processing form the main objectives of the Applied Laser Physics Group. The tools for this work are coherent optics and especially a wide use of the concept of "Fourier-Optics" and stochastic theory. An optical method tc measure various parameters usually calls for an electronical processor in which the principles of "Maximum-Likehood-Estimation" is incorporated, if possible.

The work is concentrated upon the following activities.

Robot Vision and Optical Signal Processing

The Laser Physics Group has established a collaboration about an ESPRIT project together with commercial firms and research institutes in European EC countries. The project is planned to start in January 85. The project has been approved by the EC, and only a final signment by the involved partners is missing. The total budget for the project is 42 mill. d.kr., including Risø's part of 6.8 mill. d.kr. over a five-year period. The title of the project is "The Development of an Automated Flexible Assembly Cell and Associated Human Factors Study". The lead contractor is Westland Helicopters Limited, which have the task of building the assembly cell, coordinate and integrate the work of the other partners. Vreij Universitett, Brussels, is supposed to take care of the implementation of the tactic sensors to the robot arm. Dantec (former Disa Electronics) and Risø are working together with the implementation of an optical Robot Vision system. The fifth partner, the University of Sheffield, has the human factor study as its main task.

The optical Robot Vision system, which may in fact be a hybrid optical and electronical system, utilizes the ability of parallel data processing capabilities of optical elements such as lenses, with a processing speed (in popular terms) of the velocity of light. At the moment the main task for the laser group is to develop the system architecture for the Robot Vision system. In this optical transforms which are able to give position, rotation and size invariant representation of visual information play a major role.

The Laser Gradient Anemometer

A laser-based method for measuring spatial velocity gradients has previously been described (LGA). The method is based on the combination of concepts taken from "optical processing" and ordinary laser anemometry. A conditional sampling of the scattering particles is facilitted by the introduction of a complex spatial filter in front of the detector. The detector current is thus modulated with a frequency giving the velocity difference between particle pairs with a mutual distance determined by the spatial filter.

Measurements on rotating discs have verified the concept. Later measurements on circular cylindrical flow (Taylor-Couette flow) have shown the applicability of the method for practical purposes. The advantages of the method compared with ordinary laser anemometry is the simplicity of the set-up and the sampled measurement of instantaneous velocity gradients.

The project is currently financed by the Danish Technical Research Council.

The ideas put forward in the LGA method represent a potential means for measuring one of the important fluid dynamical parameters, namely the vorticity. This possibility has been investigated, and a theoretical verification of an optical set-up has been proposed.

Marine Particles - Sizing and Sorting

In connection with a previous project reported in 1984, where an optical set-up for determination of plankton particle sizes in the range of 20 µm to 2.500 µm was reported, the potential possibilities of the system were analysed.

The probe light for size determination being monochromatic gives an opportunity to subtract inelastically scattered light from the elastically scattered light. In this way fluorescent signals from particles in the measuring volume may be extracted, revealing the chemical composition of the particles.

An investigation of fluorescent signals from phytoplankton, zooplankton and organic sedimentation products has been conducted together with measurements of the backscattering cross-section of various marine particles. The measurements have been per-

formed with and without adding membrane potential attracted fluorescent dye added to the particle environment.

Based on the results, a proposal for a laboratory equipment for particle sizing and sorting has been given.

Time-of Flight Anemometer, Space-Time Processing

The impact of particle concentration on tracking the instantaneous velocity has been investigated. Laser Doppler systems (LDA) were theoretically compared with Time-of-Flight systems (LTA).

In order to evaluate the performance of the two concepts, a coherence function reflecting the ability of the system to track turbulence was introduced. The coherence function was calculated for the two set-ups as a function of particle concentration for various values of the turbulence coherence time, the spatial averaging factor and the length scale of the turbulence.

It is argued that the LTA has the possibility of giving the best high frequency measurements of the turbulence, provided that an adequate particle concentration can be obtained.

In-Situ Measurement of Soot Particles from a Fluidized Bed Furnace

As fluidized bed combustion and large coal-based power plants have increased in number, monitoring of the solid particle content in the exhaust has become important not only from an environmental point of view, but also in order to enhance the efficiency of the combustion.

Therefore a laser-based system has been built which simultaneously measures the particle velocity in a volume of dimensions 100 μm and the particle size from approximately 10 μm to 300 μm. The system is able to work with flow velocities of 2 m/sec. and below, and the micro-processor system handles up to 700 particles per second.

The measuring principle makes the set-up very robust as a common transmitter and receiver are employed minimising the effect of refractive index turbulence and refractive materials in the beam path.

The project has been financially supported by the Danish EFP-programme.

LIDAR Measurement of Atmospheric Temperature

A five-year project sponsored by the National Oceanic and Atmospheric Administration (NOAA), U.S.A. has been terminated, and the final conclusions on the possibility of using elastically scattered light as a temperature probe have been drawn.

The investigation has shown that measurement of the spectral width of the Rayleigh scattered light from atmospheric molecules brings about a possibility to deduce the atmospheric temperature up to 15 km above ground with a spatial resolution of 50 m. To establish an operational system a mono-mode laser with an average power of 10 W and a pulse length of 100 nsec is needed. The laser wavelength should preferably be around 400 nm to enhance molecular scattering and reduce aerosol scattering which here acts as an undesired background.

The project has been the first diffraction-limited LIDAR system and has as such given many valuable results on the benefits and problems of working with a truly coherent system.

Particle Separation in Cylindrical Flow

During the work with the LGA system, a cylindrical flow was established. The fluid medium was a high viscosity fluid with monodisperse scattering particles in it. As the flow was started the initially randomly distributed particles were seen to gather in rotationally symmetrical bands in the boundary layer near the inner cylinder. The uneven particle distribution then follows "chaos-like" patterns in the flow not previously documented.

A theoretical investigation of the driving force in the particle separation has been conducted and the results submitted for publication.

An agreement between Royal Signal and Radar Establishment who is working in the field of Chaos Theory and bifurcation in flows has been made on further investigation of the phenomena.

Holographic Optical Elements

The activities of the group in the following areas

- robot vision by optical processing (ESPRIT)
- optical ranging system for the robot vision mentioned above
- vorticity Doppler system
- laser gradient anemometer (LGA)

have lead to the development of complex single optical elements as e.g.:

- an off-axis lens with 2 or more foci,
- a Fresnel lens with 2 or more foci,
- a lens having a transfer function (x,y) (Inr, θ).

Such complex lenses can only be holographically made either by simple spatial filtering of the object beam by a pinhole, or by complex spatial filtering by means of computer-generated holograms (CGH). The need for holographic optical elements (HOE) has stimulated the interest of the group in the making of HOE and the holographic recording materials needed in the recording process of the HOE.

The holographic recording material preliminary used in our process is dichromated gelatin (DCG), which is known for its ability to form volume phase holograms (allowing multiple exposures) having properties such as

- diffraction efficiency approaching 100%,
- very little scattering,
- a resolution of more than 5000 lines/mm.

The only major drawback of this material is the fact that is is not commercially available like the silverhalide materials from KODAK and AGFA, which means that we have to make the material ourselves.

We have therefore devoted a lot of efforts in the past six months of 1984 to an investigation of fabrication techniques for dichromated gelatin. As a result of this investigation a scheme has been worked out which makes it possible for us to produce dichromated gelatins.

A method known as gel casting has been chosen for coating glass plates with gelatin up to 10 cm x 10 cm and in thickness ranging

from 10 to 30 um. Apart from making the gelatin films, time has been spent on optimizing the chemical processing scheme which plays an important part in yielding a volume phase hologram with high first order diffraction efficiency and low scattering.

The sensitometric properties have been investigated, especially the ability of DCG to form laser induced grating in the dry unprocessed state, which opens up the possibility of performing various real time holographic experiments on this material, which will be further dealt with in 1985.

NUCLEAR GEOPHYSICS

General Information

The most significant event during 1984 in the Nuclear Geophysics Group was upstart of research on the use of geochemical analysis in the area of oil and gas exploration. Projects in this new field have been launched with support and participation from companies and university scientists involved in studies and exploration of domestic source and reservoir rocks. The purpose of the work started is to identify chemical elements which supply geological information on oil and gas potentials. Accordingly, sample material from exploration drilling is being analysed for characteristic elements in support of wireline borehole logging of geophysical rock parameters. A pilot study carried out with government funding has demonstrated that instrumental neutron activation analysis (INAA) has potential as a tool for geochemical characterization of the chalk formations in the North Sea which feed the oil and gas wells of the Danish off-shore industry. Promising results have also been obtained with gamma-ray analysis of cuttings retrieved from drilling mud. It is presently being investigated to what extent the measured radioelement concentrations can be used as an aid to the interpretation of gamma-ray wireline logs.

Another new working field taken up in 1984 is airborne assessment of snow cover based on the attenuation of the natural gamma-ray flux from the ground. During the next several years the government plans to monitor the annual snowfall various places in Greenland where an adequate amount of water may be collected for the production of hydroelectricity for consumption in nearby small communities. The long-term nature of the snow monitoring programme involves repeated gamma-ray flights with reliable equipment. It has therefore been decided to renew the airborne instrumentation through the procurement of new large sodium-iodide detectors.

The group has furthermore extended its activities by doing work on the design of nuclear gauges in general whenever such work might be justified scientifically or result in an industrial research contract. In 1984 a manufacturer of machinery for the dairy producers was assisted with the design of a gamma-ray density gauge which measures the weight quantity of milk delivered by the farmer.

The takeup of new R & D topics coincides with a marked decline in older activities with relation to uranium exploration. Although significant uranium findings have been made in Greenland over the past few years, the group does not foresee any major prospecting operation in the near future. This is a consequence of the present low uranium prices plus indications that nuclear power will be removed from the Danish energy planning. Ground follow-up on a occurrence of uraninite in the migmatite zone of South Greenland was performed in August 1984 under the so-called SYDEX programme which expires at the end of 1985. Also, the international uranium exploration R & D started in 1976 by NEA and IAEA, to which the group has yielded a rather strong contribution, terminated in 1984.

Four short technical contributions are included in this progress report to illustrate some of the developments and research results achieved in 1984.

Completed Contract Research on Radiometric Calibration

The 1983 progress report contained a summary of a four-year research project carried out for the IAEA in relation to the measurement of radioactive ground concentrations by means of portable and airborne gamma-ray spectrometers. A final report on the work done was submitted in September 1984. The following summary will provide an impression of the scope of the investigation and the results and conclusions obtained:

To get a portable or airborne gamma-ray spectrometer calibrated as a radiometric assay tool, the survey operator must have access to large and plane slab sources of known radioelement concentrations. Over the past several years, survey organisations in more than ten countries have built concrete calibration pads which are up to 9 x 12 m large and contain evenly dispersed aggregate particles of K-feldspar, pitchblende, thorite, or other naturally radioactive material. Twelve of these facilities were monitored with a portable spectrometer. The monitoring data used in combination with other sources of information suggest that an adequate calibration facility is formed by three pads spiked with a predominant content of either potassium, uranium, or thorium. An additional pad of low radioelement concentration must be included to eliminate the background contribution from the surroundings. Uranium and thorium pads of the desired radioactive purity and homogeneity is best manufactured by mixing powdered high-grade ore into

quartz sand of about 3 mm particle size. The uranium ore should be of negligible radon emanation power. Calibration pads for portable spectrometers are conveniently constructed by placing the wet mixes in circular metal containers, approximately 2 m in diameter and 50 cm deep. Grades of 100 ppm eU and 200 ppm eTh are useful calibration levels for on-the-surface assays in general.

Concrete (mortar) based on fine aggregate must be expected to be 20% porous and absorb up to 10% moisture in an outdoor environment. It is relevant to include the average pad moisture in the calibration grades with subsequent inclusion of the seasonal moisture variation of perhaps 6% as an additional grade uncertainty. In-situ pad grades can be estimated quite well by gamma-ray analysis of freshly cured concrete in sealed sample cans. Spectrometer counts recorded on calibration pads are conveniently processed by means of weighted, 3-dimensional regression analysis. Simple working expressions make it possible to include calibration uncertainty as well as counting statistics on the assay spot in the standard deviations on recorded radioelement concentrations. An airborne spectrometer can be calibrated reasonably well by combining a calibration trial on pads with theoretical corrections for atmospheric gamma-ray attenuation. The normal practice of determining the window sensitivities from flights over a test range presupposes a ground of moderate moisture content and little radon exhalation.

Computer Simulation of Detector Window Responses

In airborne gamma-ray assays of radioelement concentrations in the ground or the water equivalent of snow cover one must know the attenuation per surface mass unit of air or snow. The theoretical prediction of mass attenuation factors is based on model calculations in which the ground is simulated by a plane and evenly radioactive source medium. Several years ago the Nuclear Geophysics Group in collaboration with Dr. P. Kirkegaard of the Computer Installation at Risø developed a programme system for calculating the angular and energy characteristics of the gamma radiation from such a medium. The system utilizes data files containing up-to-date information on the involved emission lines and gamma-ray interaction cross sections.

To calculate an actual spectrometer window count rate, it is necessary to combine the estimated flux in an airborne survey altitude with the window response of the gamma-ray spectrometer.

This is mainly a question of setting up a reliable model of the way a large sodium-iodide scintillation detector functions. In a recent response model developed for cylindrical NaI(Tl) crystals, the interaction histories of the incident gamma-rays are traced by the Monte Carlo method. The computer programme supplies the counting probability selected by the lower limit of an arbitrary energy window. The attached figure shows three resulting response curves calculated for a detector crystal which is 15 cm in diameter and 10 cm thick. A window response is provided by subtracting the response curves for the two associated window limits. A previously developed analytical code is used for calculating absolute window efficiency as a function of the energy and angle of the radiation from the ground.

Gamma-Ray Analysis of Weakly Radioactive Material

The Nuclear Geophysics Group operates a laboratory gamma-ray spectrometer which consists of a 15 x 15 cm NaI(Tl) detector mounted within a heavy background shield and supplied with a magazine and an automatic feed mechanism for the samples. A sample if formed by about 250 g of material packed into a sealed metal container. For a long period of time the equipment was almost exclusively used for radioelement assay of crushed rock originating from areas of uranium mineralization. This main application justified the application of window counting using energy windows centered on the prominent peaks from potassium, uranium (radium), and thorium radiation in the spectral range above 1.46 MeV. The new analytical tasks in connection with deep drillings in Denmark necessitated the development of an improved counting technique which would offer a precise determination of uranium and thorium contents at the parts per million level.

The gamma-ray spectrometer is now set up for full spectrum recording with the subsequent use of a least-squares method for measuring a set of radioelement concentrations in weakly radioactive material. By using reference samples of different weights it has become possible to utilize the spectral region down to 150 keV without introducing assay error caused by Compton scattering from high to low gamma-ray energies. Calibration runs incorporating the recording of background counts for 55 hours is normally performed over the week-ends. The background appears to be stable to within 5%, indicating that the radon level in the counting room is acceptably low.

In the attached plot of laboratory gamma-ray spectra, the dots represent a sample spectrum measured for 1.4 hours. Radioelement concentrations suggested by the associated fitted spectrum are shown at the bottom of the figure. In this particular assay the goodness of the fit is described by a chi square value of 1.0, suggesting that the assay result and its uncertainty are reliable. It should be noted that a sample of this small radioelement content produces a rather weak net signal over the background, especially in the energy range above the potassium-40 peak (channel 146). The spectrometer is situated in an unheated basement enclosure, so that gain drift due to temperature variations is kept at a minimum.

Dispersion of Niobium and Phosphorus in Soil Overlying a Carbonatite Complex

Phosphate rocks are extensively used for the manufacture of fertilizers, and occurrences of carbonatite are here of interest as a potential raw material for the European producers. The following exploration of a carbonatite complex in Greenland was carried out in collaboration with The Geological Survey of Greenland.

The Mesozoic Qaqarssuk Complex is located at the west coast of Greenland. It covers 15 km^2 and includes a predominantly carbonatite ring dyke structure surrounded by fenitised basement. The suite of igneous rocks known from the complex comprises carbonatites (sovite and rauhaugite) and various ultramafites. Carbonatite dykes (beforsite) are cutting the complex and its surroundings and late magmatic veinfillings of calcite, dolomite and/or rare earth carbonates are observed. The fenitised basement rocks are of Na-fenite type. The complex is covered by at least 0.5 m arctic soil of mixed glacial and residual pedigree. It is argued that Nb and P are enriched in the soil and thus, regolithic accumulations might occur, developed during the short time available since last glaciation.

Soil sampling on a 10 m grid (304 samples) was carried out and rock samples (102 samples) were taken within the complex and from carbonatite dykes outside the complex. All the samples were analysed for a number of major and trace elements by X-ray fluorescence techniques and by delayed-neutron counting for U. Major elements in the rocks clearly outline the transition from gneiss to carbonatite by increasing contents of CaO, MgO and P_2O_5 at decreasing SiO_2 and Al_2O_3. Fenitisation is flagged by an

increase of Na_2O. The carbonatites can be grouped as originating from two magmatic phases according to their CaC and MgO contents. Carbonatites have an average of 1.7% P_2O_5.

Based on the soil sampling, it has been concluded that:

1) Soils are significantly depleted in Ca and subsequently enriched in Mg and Fe (solution of calcite in CO_2-bearing waters).

2) P is enriched by a factor of 2 or more compared with carbonatites. Soils with P accumulations often have low Ca contents. CaO/MgO ratios of less than about 1.5 in soil may point to secondary apatite enrichment in the Qaqarssuk environment.

3) Nb and U anomalies, not usually coinciding with apatite enrichment, reflect pyrochlore rich rocks beneath the soil cover (upwards migration of Nb and U).

The investigated soils have received little or no contribution from glacial material. Secondary precipitated apatite was not observed. The carbonate mineral content in the primary carbonatites and overlying soils shows a pronounced difference with a predominance of dolomite in the latter.

In general, geochemical exploration methods using arctic soil sampling within the Qaqarssuk Complex have proven to be suitable in mapping and prospecting at a local or regional scale.

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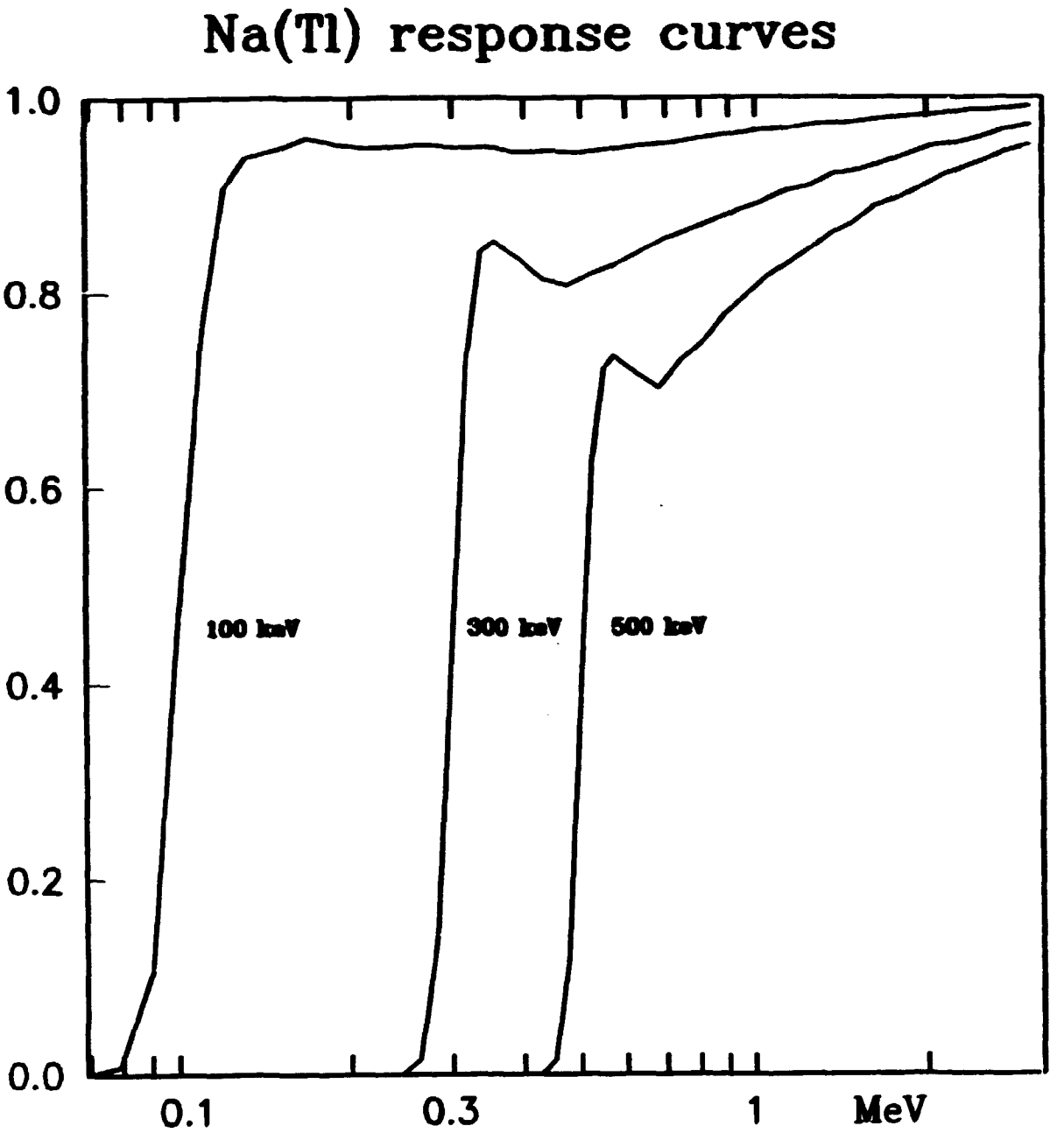

Fig. 1. Response of a large NaI(Tl) scintillation crystal (15 cm in dia., 10 cm thick) for threshold energies of 100, 300, and 500 keV. The curves are normalized to a gamma-ray interaction efficiency of 100%.

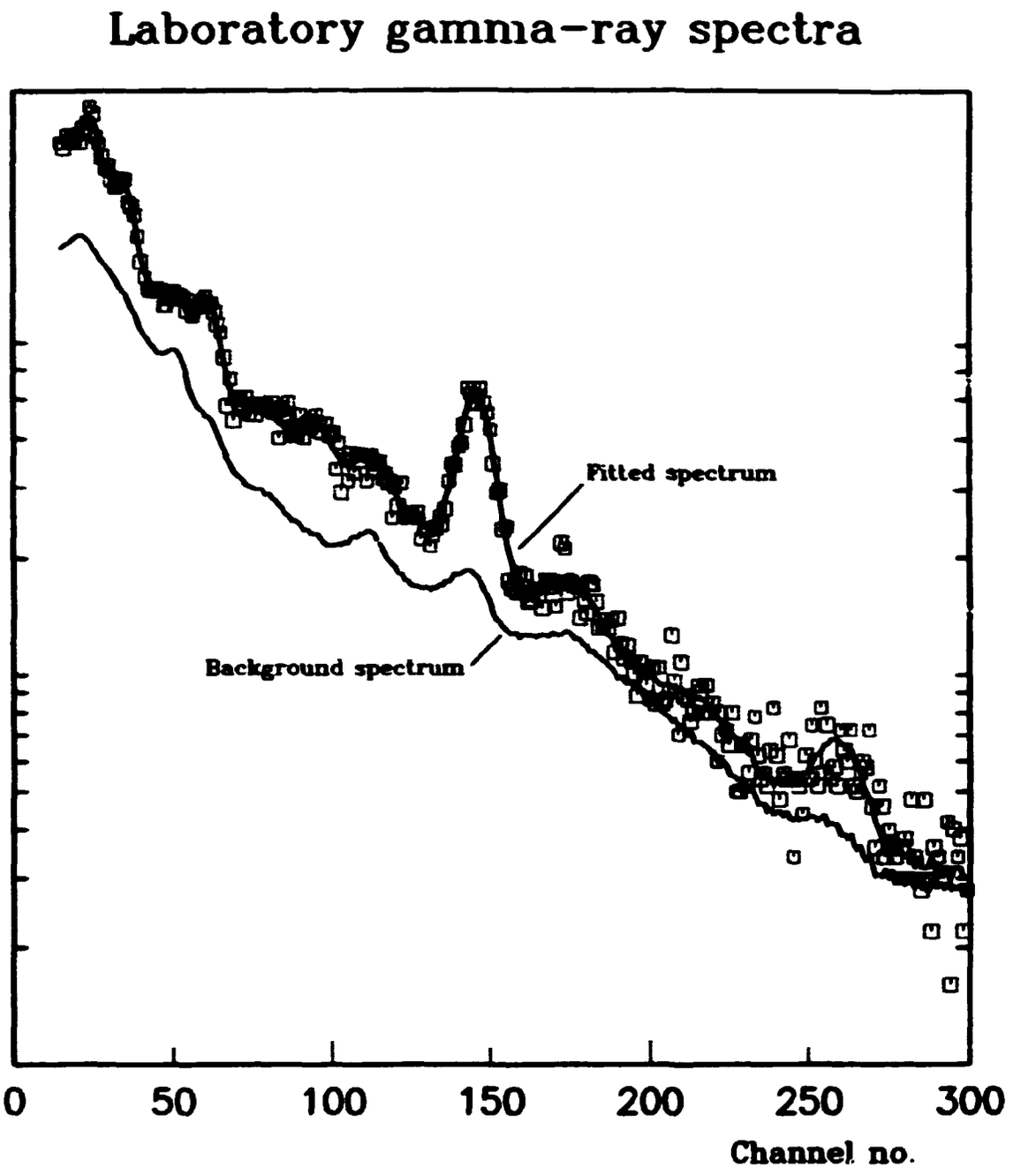

Fig. 2. Experimental spectra (sample and background) recorded with a laboratory spectrometer. The sample had a net weight of 245 grams, and the fitted spectrum shows that it contains the following natural radioelement concentrations:

0.931	+-	0.029	% K
1.98	+-	0.08	ppm U
4.83	+-	0.19	ppm Th

SIM - SECTION FOR INSTRUMENTATION AND MEASURING TECHNIQUES

X-Ray and Neutron Spectrometers

An instrumentation has been developed for a new x-ray spectrometer, which is used for solid state physics experiments carried out by the Physics Department at DESY in Hamburg. The instrumentation is based on our traditional standard PDP-11/CAMAC scheme, this time with a Micro PDP-11 with a Winchester disk and a mini floppy disk. A new development is a motor multiplexer in EURO standard for up to 32 stepping motors. Each motor is connected to its own drive, but there is only one power supply for a group of 8 motors so that only one of the 8 motors may run at a time. Each group of 8 motors is controlled from one CAMAC module. A software package enables the user to select motors, specify and read motor positions, and have up to four motors running simultaneously.

Another new development is the installation of the multiuser operating system TSX on this X-ray spectrometer instrumentation as well as on one of the neutron spectrometers. This installation required a great work with adaption to TSX of the existing RT-11 software for the CAMAC system, plotters, data transmission, etc. With TSX on a spectrometer up to three jobs may run at the same time. One job could be control of the spectrometer, other jobs could be data reduction, program editing, etc.

Computer Software for Transient Spectroscopy Experiments

A new package of application programmes was installed in the PDP-11/23 based instrumentation used by the Radical Chemistry Group of the Chemical Department, to run resonant Raman spectroscopy experiments.

The instrumentation comprises a gated-intensifier, SIT-TV camera, CAMAC ADC, and I/O modules, a PDP-11/23 with 5MB hard disk and floppy disks, a Tektronix 4025A terminal, a plotter and a printer.

The FORM mode of the 4025A is used to insert parameters in a set of forms defining the instrumental set-up, the chemical system used in the experiment, and the defining parameters. Parameter values may be numeric values or text strings. A Parameter Module

in the programme transfers the actual parameters to global arrays. A data module controls the gathering of spectrum data, displays these raw data together with selected parameters and, if accepted by the operator, files the data and parameters. The data may also be transferred to a storage area where, in the present program, up to 10 related experimental spectra may be stored. In a display module these stored spectra can be displayed and calculations such as smoothing, subtraction, peak-integrations, etc., can be done and results filed. The abscissa can be selected as channels, wavelengths or wavenumbers.

In a calibration module measured spectra with known peaks can be checked against line spectra from library-files and the set of assigned lines are used in a fitting routine to find the constants in a second order polynomium that corrects the abscissa for non-linearity in the detection system.

A catalog file (random access) is continuously updated with the names of data/parameter files produced, together with salient parameters from each file. The calalog controls the exclusive numbering of the files and the status of each file: protected, backed up on floppy disc etc. The catalog is also used by a search module in which, by means of a form, the operator can specify parameter values or range of values. These values (numeric and text) constitues a model used by the search module to explore the catalog for files matching the model and print out the file specifications.

After the operator has closed an experimental session, typical after a days work, a back-up programme controls the copying of files from hard disc to security back-up floppy discs, using the catalog. Another program prints pages to a log book. Hard copy plots may be made from files describing screen pictures made in the display module.

The operator-computer communications are, besides the forms, based on menues showing possible next steps in a given situation; but also command-strings with sequences of steps may be used by the experienced operator.

Silicon Irradiation

Instrumentation of silicon irradiation in DR3 is spread out over three projects.

Plans were made for an instrumentation for a new 5" rig. This is a modified version of the 3" and 4" equipment which is operational. The rotating irradiation facility is supplied with three self-contained neutron detectors for determination of the integrated flux to which the Si-crystal has been exposed.

One of the detectors determines whether the irradiation shall be stopped automatically or not. The two others are spare parts or are used for comparison. The amplifiers have been developed recently, and the dose integrators are now produced by Jensen Electric. The flow measurement equipment has been replaced by a much more competitive Danish product (H. F. Jensen).

It is supposed that test and running of the instrumentation will take place during the autumn of 1985.

In addition, the group has participated in the maintenance and modification of existing equipment. A modular and thus more serviceable panel for operating the rotation of the Si-crystal was instructed. A satisfactory test of the surveillance of the Si-rig rotation has been carried out.

The group has also participated in a planning group investigating suggestions for a horizontal Si-facility cooled by light water.

The instrumentation shall control, monitor and document the operation of the irradiation rig. It has been placed on the second floor of DR3. A manual as well as a fully automatic facility are being considered. The automation includes the insertion and removal of the Si-crystals. Circuits are present for manual and computer-controlled selection of rotary speed and for start of high speed removal in case of an emergency.

Economic considerations necessitate a high measure of precaution for movement of the crystal. This requires hardware as well as software surveillance of the movement.

The customer's demand for neutron dose and the measurements of position and flux enable the computer to calculate the movement of the Si-crystal. The computer automatically prints the flux integral when irradiation has been completed or in the case of a stoppage.

The control of position and identification of the Si-crystals during transport, irradiation and storing is of vital importance

because a mistake may be expensive. Naturally the instrumentation is supplied from the no-break power supply of DR3.

Instrumentation of Storage Tanks

The tanks for storing radioactive waste water and cooling water from seven Risø departments (including the instrumentation for surveillance of the degree of filling and the control of storing and draining) are ready for decommissioning. The difficulties in getting spare parts are increasing. Because of the fact that the existing installations were constructed at the time Risø was opened, the Security Department recommends the installation of technologically up-to-date equipment.

Having visited several similar Danish plants controlled by microcomputers, we have designed a new instrumentation based on the PCC863 from Saab Scania.

The control center will remain in the laboratories of the Waste Management Plant. In a couple of years when the new equipment has been fully installed, the microcomputer will handle 200 digital in/outputs and 25 analog inputs.

The switchboard containing instruments displaying the quantity of water will be replaced by a data terminal with text and bar diagrams. A printer will give a report once a day, and each time one of the 75 limit detectors is activated, or at the request of the operator.

The microcomputer controls the storing of waste water, the agitation by means of compressed air and the draining.

An IBM personal computer will be used for programming.

The instrumentation of the specific tank positions will include solid state relays and local power supplies because the distance is around 2 km.

The environmental conditions in the tank pits are cold and damp. For that reason, the motor-controlled valves will be replaced by electro-pneumatic valves and H. F. Jensen electrical pressure transducers will be used for level detection.

In 1985 the central instrumentation will be ready for operation and the four tanks near the Waste Management Plant will be installed.

The planning is doing done by the Security Department, the Waste Management Plant, and the Electronics Department.

Cold Neutron Source (CNS)

In cooperation with the German company Interatom Risø has entered into a contract with the Research Establishment of Geesthacht concerning delivery of a cold neutron source. The facility changes the neutron beam from a nuclear reactor such that the relative content of slow neutrons is higher than normal.

Risø has experience from about ten years of operation with a source like this.

Last year we took part in the basic design. The work includes, for instance, the setting up of guidelines for operation, surveillance, and control of the plant.

We generated the basic specifications concerning the instrumentation and location of the electrical components and power requirements inclusive of a no-break power supply. Furthermore we worked out the main specification of the sensors, transducers, and the limit conditions of warnings and experimental and reactor trips.

The demand for a high measure of precaution includes that the surveillance and control equipment of the facility consists of a hardwired part, which maintains the CNS in a safe condition. To prevent unnecessary interruptions of the operation, shutdown actions will not be carried out till two out of three identical parallel measuring channels indicate a limit excess.

A computer system will advise the operator during start-up, normal operation, and run-down of the facility. The computer will print out the state of the operation for documentation once a day, and each time a failure occurs, or at the request of the operator.

Fuel Element Research and Development (R&D)

During the year 1984 the PGE bench instrumentation has been modified to include a new VAX computer, and to make this computer a multiuser system a micro computer card in EURO standard, to take over the time requiring part of the positioning was constructed. The hardware and software is under test and final adjustment.

To change the very expensive digitizers in the positioning system on the bench into brushless resolvers, interface cards have been built to convert the resolver signals into digital information in BCD. To the translation system a card has also been built for counting of the resolver turns to give the absolute position, and for saving of the latter even during some time of power failure. To minimize the time necessary for the VAX computer to position the microscan XY board two stepping motor drives P1062 are under modification.

Dynamic Pylon Measurements at the Farø Bridge

An instrumentation for making dynamic measurements on a PYLON belonging to the Faroe bridge which connects Sjælland and Falster has been constructed. The purpose of the measurements was to monitor the 95 m concrete PYLON during the critical phases of the erection of the bridge and also to verify the design basis.

The instrumentation comprises meteorological sensors mounted on a meteorological mast erected on the top of the PYLON measuring wind speed, wind direction, and temperature.

In addition structural sensors measuring linear and angular accelerations together with inclination are mounted at the top of the PYLON.

The conditioned sensor signals are fed in parallel to an FM tape recorder and a data acquisition unit which contains a 10 channel relay multiplexer and an analogue to digital converter. Both instruments are controlled by a battery backed-up microcomputer. All signals are continuously scanned by the data acquisition unit and once an hour statistics in the form of mean values and variances are output to a printer. Furthermore the signals are recorded on the FM tape recorder for predetermined time periods when one of the linear accelerations or the wind speed exceeds a

threshold. These recordings are of a sufficient bandwith to permit the calculation of power spectra of the recorded parameters.

Investigation of Deuterium Pellet Acceleration by an Arc Heated Gas Gun

This investigation is carried out as a feasibility study for the JET project in England. The goal is to exploit the limits of the arc heated gas gun concept for acceleration of deuterium pellets used to fuel the JET device. The working principle in an arc heated gas gun is to achieve high pressure propeller gas by creating an electrical arc in a hydrogen filled chamber. The dissipation of the electrical energy in the chamber causes the gas temperature and pressure to increase rapidly. A too rapid pressure increase will, however, break the pellet, and a too slow one will not accelerate the pellet sufficiently.

A large arc power supply has been designed with the assistance of external consultants. This power supply has a controllable discharge rate, and can dissipate a maximum of 5 KJ in the arc.

The diagnostics equipment for the gun measures the pressure in the chamber, as well as the pressure at three different points of the gun barrel. Time of flight and hence acceleration in the gun barrel is measured by means of a set of eight light beams guided to and from the barrel by fibre optic cables. The pellet mass is measured in three ways. First, the pellet passes a microwave cavity creating an electrical signal proportional to the mass. Next it hits a pendulum causing it to deflect, and finally it evaporates in the chamber containing the pendulum and causes a pressure increase. Other parameters measured are arc current and voltage. Finally the pellet is photographed.

The diagnostic system is based on a minicomputer, and all data are stored on magnetic disks and presented on log book sheets as well as in graphic and text form.

Klystron Power Supply for Plasma Physics

The most important job performed for the plasma physics section in 1984 has been the design and construction of a 22 kV - 3,5 A power supply for a klystron. The klystron will be used for microwave heating of the plasma in the DANTE Tokamak experiment

at Risø. The power supply as such is very simple, but an elaborate system of monitoring circuits has been included to reduce the risk of damage to the klystron in case of malfunction.

Washing Machine Instrumentation

A washing machine in one of Risø's radioactive areas has been installed with an IC-microcomputer to control the process.

Different programs are stored in a 2716 EPROM AND A 8748 microcomputer controls time and I/O functions for every step in the program chosen.

The operation under progress can be manually delayed or shortened, or the process can be stopped either with output functions activated or not. A no-break supply places the washing machine in standby-mode if the mains fail.

Main functions under control are water, steam, and soap injection, while measurements comprise level, temperature, weight, and volume.

Single Point Thomson Scattering System

The installation of the Single Point Thomson Scattering System, built for JET (Joint European Torus) in England, was completed in May. The system measures the plasma temperature using Doppler shift of laser light. Due to the radioactive environment, it is designed for remote control by means of actuators like pneumatic and electrical stepping motors, and remote sensors like resolvers, linear displacement transducers and fibre optic sensors. The system showed remarkable stable operation, and turned out results that deviated only slightly from the predicted figures. Later it showed up that this deviation was caused by a minor optical error, which has now been corrected. The results from the Single Point Thomson Scattering System are now used at JET as reference for other diagnostic measurements.

Fast Beta- and Gamma-Ray Spectroscopy

In many nuclear applications there is a need for energy measurement using high resolution X- and gamma-ray spectroscopy at fairly high counting rates, in particular at nuclear chemical

plants, reactor shielding experiments, neutron activation analysis and in experiments using synchrotron radiation.

At the Danish experimental reactor, DR3, a fast capsule transfer system, Mach-1, for neutron activation analysis (NAA) of short lived isotopes is installed. The detector equipment consist of a Cerenkov scintillator for beta-ray counting, and has been supplied with a wide band amplifier and a discriminator using the constant fraction technique. This beta-detector channel is able to handle count rates in excess of 500.000 counts per second and still keep the count losses, due to the dead time, at an acceptable level.

To increase the value of the equipment the Electronics Department is about to build a gamma-ray spectroscopy amplifier also capable of handling input count rates in excess of 500.000 counts per second. This is done by using a new technique named cyclic gated integrator. This new technique should overcome the shortcomings of the conventionel gamma-ray spectroscopy amplifier and reduce the limitations of a gamma ray spectroscopy system solely to the finite charge collection time in the detector. This is done in cost of a slightly decrease in energy resolution. This expansion of Mach-1 gives a opportunity to perform coincidence measurement between beta- and gamma-ray experiments.

Standards and Common Practices in Electronics for Research Establishments

SIM participates in European collaboration on standardisation and pre-standardisation in the field of real-time use of data techniques. This is done within the framework of the two organisations ESONE (European Standardisation on Nuclear Electronics) and ECA (European CAMAC Association). Both organisations have developed far beyond what their names indicate in the real-time computing field. ESONE finished a complete revision of the CAMAC standards documents and the first stable version of the FASTBUS specifications is available. ESONE is also working on possible common practices in local and wide area networks, on the use of the VME bus, a backplane bus for interface systems, on small computer systems and on software for distributed microprocessor systems. The activity mentioned last is also an activity of the ECA; this organisation, however, had only little activity in

1984, because the CEC, which supports the ECA, is reconsidering its activities in the information techniques standardisation.

Instrumentation Consultance to the Science Research Council

In connection with a fairly large grant for renewal of worn-out larger instruments in Danish universities, a considerable effort came from SIM to the researchers, especially in the field of computer interfacing and software.

FRIT
INSTRUMENTATION CONSULTING, REGISTRATION, AND MAINTENANCE FOR THE DANISH RESEARCH COUNCIL AND RISØ NATIONAL LABORATORY

Introduction

FRIT is a co-operative venture between the Danish Research Council and the Electronics Department of Risø National Laboratory to provide a joint instrument service. The purpose of FRIT is to support Danish research at Risø as well as elsewhere by:

- Acting as consultants in the selection of instruments and apparatus.
- Purchasing and registering apparatur.
- Lending instruments and apparatus.
- Instrument servicing at regular intervals.
- Instrument repair.

Consulting and Purchasing Activity

The consulting group's activity in 1984 was centered mainly on the following three institutions:

Risø National Laboratory
Purchase of apparatus for research and contract projects - in 1984 a total of 415 for a value of 10 million Danish crowns.

Research Councils
Purchase of apparatus for researchers supported by the councils - in 1984 a total of 367 for a value of 25 million Danish crowns.

Ministry for Education
Purchase of apparatus on the basis of an extra-ordinary appropriation. These are/will be located at the various universities and other institutions for higher education. These acquisitions will take place over a four year period; in 1984, 128 purchases were made with a total value of approx. 24 million Danish crowns.

All the purchased equipment becomes part of the central instrument depot after an incoming inspection. This depot is under FRIT's control. From here the equipment is loaned out to users - e.g. those receiving special grants.

This central purchasing and loan service leads to a number of advantages for the user institutes:

- Discount arrangements with the more important suppliers.
- Standardized purchases.
- Solid basis for acquiring experience.
- Better utilisation through the loaner arrangement.

FRIT's total store of equipment was at the end of 1984 approx. 11,000 with a total value of 246 million Danish crowns.

FRIT's loaner service is intended for researchers who have a need for special equipment for shorter periods of time or for researchers who otherwise do not have the means for acquiring their own facilities.

This source is available - both for Risø's researchers as well as for those of the universities and other institutions for higher education. This loan service is gratis.

An effective loan service is ensured by means of an established co-operative effort among the registration organs at the various participating institutes. This cooperation is formalized via a "registration committee" which has now been active for almost ten years. Among other things, this committee issues complete listings of the equipment and apparatus assigned to the various institutions.

Service and Repair

All apparatus which is purchased for Risø is subjected to an incoming inspection in Risø's service group. In addition, this group provides maintenance for this equipment without any charge to the user.

This service is offered - on a smaller scale - for the equipment purchased via the research councils while assistance and consulting in connection with own maintenance are provided.

2,000 repairs and inspections were made in 1984 on Risø's own

apparatus while about 250 repairs were made on equipment acquired through the research councils.

In addition to these types of service, the group performs maintenance tasks on special equipment - mostly those utilized in Risø contracted projects.

DEPARTMENTAL ADMINISTRATION

Attempts have been made to apply some of the concepts which have been developed for describing and evaluating the interaction of humans with complex technical systems in an administrative context; namely in connection with the administration of the Electronics Department itself. In particular there was an interest in trying to define a suitable display set which could satisfy the needs for information as clarified by an analysis of the activity at various levels of abstraction. Figure compares elements of description of a power plant and an organisation such as the department at some possible levels while figure illustrates examples of two types of relevant information at these levels. A start towards the implementation of a computerized system is now being made which will make use of a local net of microcomputer-based work stations using mainly commercially available programs to test the ideas.

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ELECTRONICS DEPARTMENT
PROGRESS REPORT 1984

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Abstract

This report summarizes the activities in the Electronics Department in 1984. These include work under the headings of informatics, applied laser physics, nuclear geophysics, instrumentation and measuring techniques, and instrumentation consulting, registration and maintenance for the Danish Research Council and Risø National Laboratory.

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